



New Laser Capabilities for the Future of Quantum Information

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M Squared Lasers

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Introduction to M Squared Lasers

- Next generation lasers and photonic systems
- Growing presence in AMO community, especially trapped ions
- Broad portfolio of systems from deep-UV to THz, CW to fs
 - SolsTiS:** ultra-stable CW Ti:Sa laser
 - ECD:** resonant enhancement cavity for frequency conversion
 - Sprite:** pulsed fs Ti:Sa laser
 - Firefly:** mid-IR & THz OPO
 - Dragonfly:** mode-locked ps semiconductor laser
- Sealed, alignment-free cavity with optics fixed in the factory
- Low-stress retention and low thermal sensitivity.
- Laser control via web browser from anywhere in the world
- Active participant in collaborative innovation projects:
 - Leading 20 projects, involved in 25 total projects
 - \$22 million under M Squared's management
 - Funded by UK, European, and worldwide programs
 - Supporting all four UK Quantum Technology Hubs

Potential Roles in LogiQ

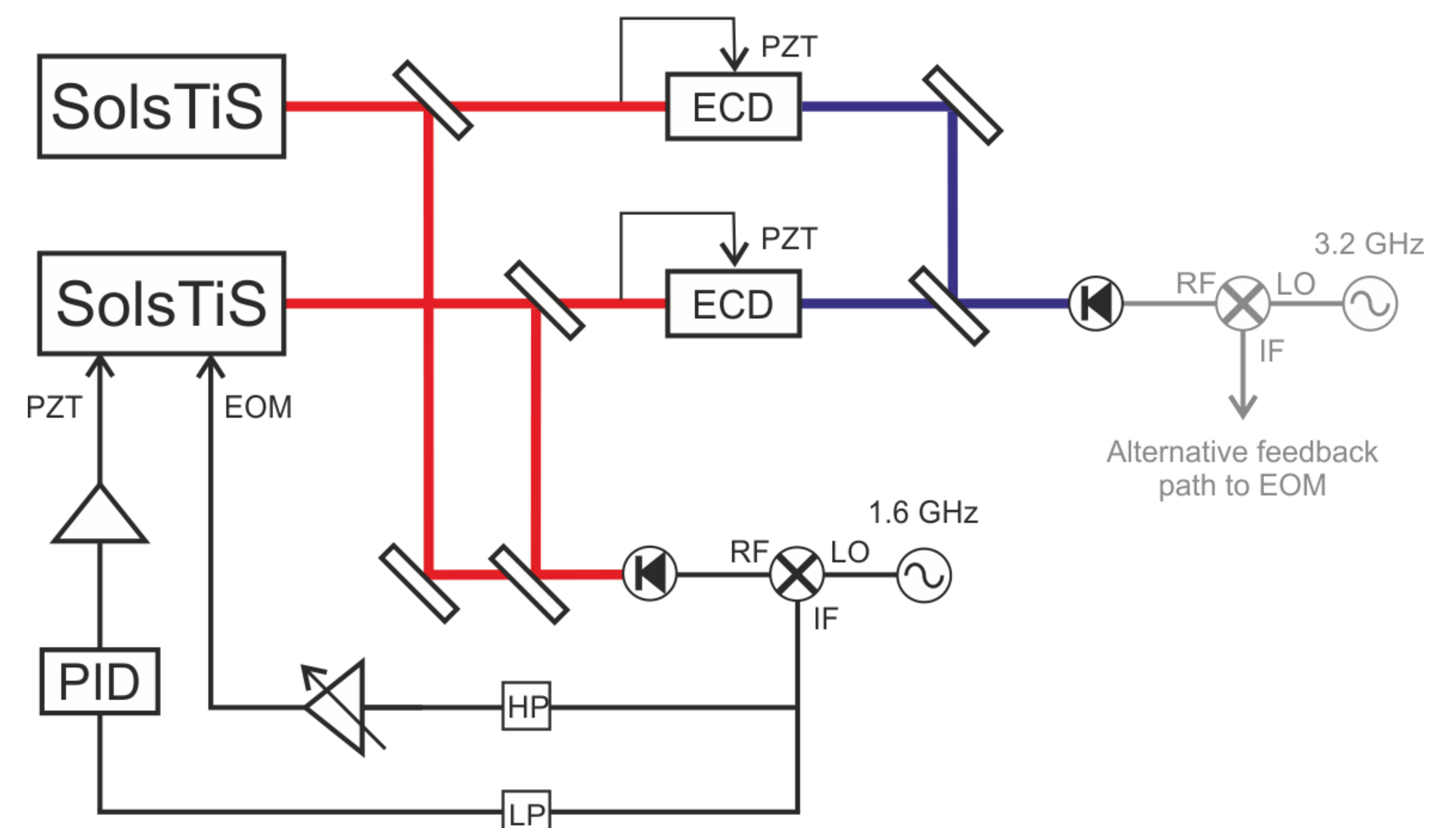
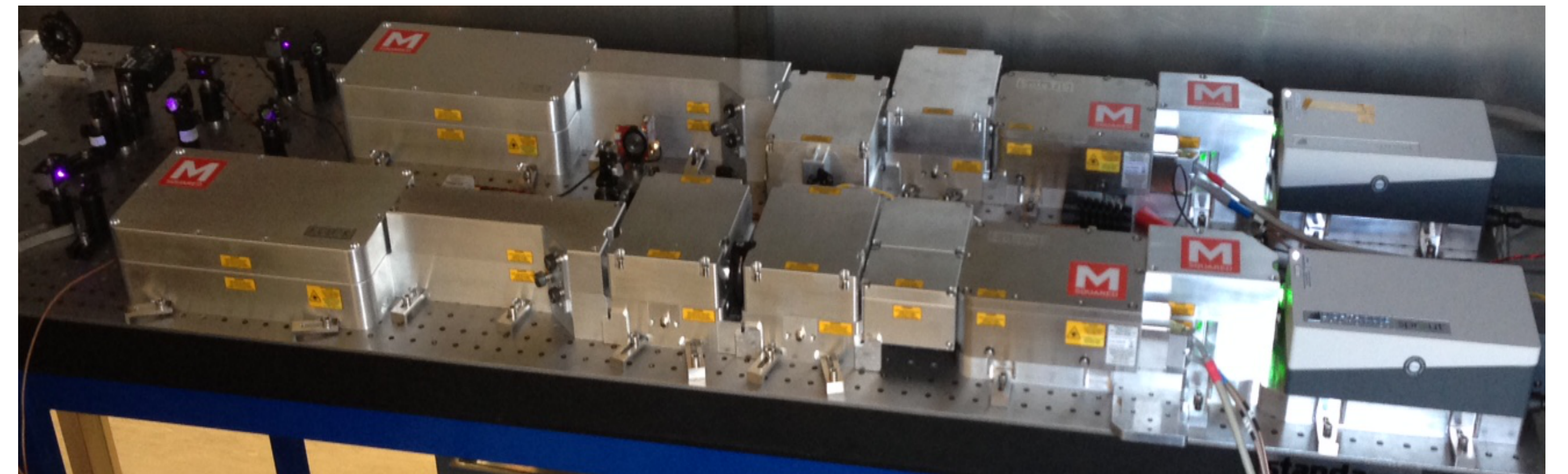
- Provide laser and electronic control systems
- Custom engineering capabilities:
 - Speed-up system builds
 - Technological sophistication: low noise, ultra-stable
 - Enhanced performance
- Seeking to extend the capability of our existing laser systems
- Partnerships to commercialize spin-off technologies

Expertise

- Widely tunable Ti:Sa lasers
- Unique alignment-free, ultra-stable opto-mechanics
- Super quiet electronic control systems accessible via the web
- High power: > 6 W in the near-IR, up to 3 W in the UV / blue
- Ultra-narrow linewidth: < 50 kHz free-running
 - Down to ~ 1 Hz when locked to a high stability reference
- Low intensity noise: 0.02% RMS
- Frequency conversion to UV
 - e.g. 235, 267, 280, 285, 313, 369, 397 nm

Custom Project: Phase Lock Module

- Two SolsTiS lasers phase-locked together
- Offset between 100 MHz and 6.4 GHz
- Digital frequency-phase comparator for lock capture
- Analogue mixer for ultimate noise performance
- Phase noise down to -120 dB/Hz at 100 kHz
- RMS phase error < 0.01 rad (10 kHz to 1 MHz)
- Spans 3.2 GHz hyperfine splitting at 397 nm in Ca⁺
- Raman transitions for high fidelity gate operations



Custom Project: Resonant Modulation

- Generate 2.1 GHz sidebands at 369 nm
 - Spans hyperfine splitting of ¹⁷¹Yb⁺ for state-preparation
- Side-step challenge of electro-optical modulation in the blue
- Phase modulation directly on near-IR fundamental beam
- Resonantly double carrier + sidebands in enhancement cavity
- Fast digital switching: complete >99.9% extinction of carrier

